

SCIENCE

NEW YORK, AUGUST 28, 1891.

ALCHEMY.¹

WHEN I announce alchemy as the subject of my address, a word of apology is due for selecting a subject so outgrown and alien to the spirit of the age. It is not to revive the wild theories and chimerical hopes of the past that alchemy is brought before you at this hour. Yet it is always interesting to trace the evolution of a science, and to note its unfolding and progressive development, like the breaking of the morning. The dawn reveals wild shapes and distorted forms, the shadows of sunrise stretch out limitless, but with the onward sweep toward full day, portentous forms and endless shadows settle down to the safe and quiet realities of every-day life. So the wild dreams of that dawn of science have subsided into the assured facts of chemical science. Alchemy is often called the forerunner of chemistry, and out of its broken columns there has been built up the enduring temple of chemical science. No science has a more enduring basis of known facts than chemistry, and none can more calmly examine the basic principles upon which it is built without fear that the foundation stones will turn to dust upon the touch of investigation.

But no science comes to us like Minerva leaping from the brain of Jupiter,—“adult and full armed,”—possibly because Jupiters are so rare, and the bold surgery of Vulcan so seldom invoked. The passage from alchemy to chemistry is full of suggestions, and has often been considered, but usually by contrast rather than comparison. One filled the world with vast hopes but unsatisfied longings; the other has crowned the race with benefactions. Yet the results of the labors and discoveries of the alchemists have been of great value to the world, even though the direct objects they sought forever eluded their grasp and left disappointment and despair to their votaries. More than a hundred years ago Harris tersely described alchemy, “*Ars sine arte, cujus principium est mentiri, medium laborare, et finis mendicare*,”—the art without art, whose beginning is to lie, the middle to toil, and the end to beg.

We are prone to look back upon this nebulous science with disdain as the product of an age that had full confidence in magic and sorcery, that could accept without hesitation the elusive nature of matter, yet find no difficulty in the belief in the resistless power of occult forces. But let us be candid even in our review of ancient error. Let us see what were the hopes and aspirations of these hermits of science, and see how modern thought stands related to ancient dreams—whether we find in scientific thought, the same as in matter, a tendency to move in recurring cycles.

The objective points of the alchemists were:

1. *The Elixir of Life*, panacea, all-cure, a substance which would confer quasi-immortality upon any one who should swallow it, curing all sickness, assuaging all pain, and transforming hoary age into blooming youth. It was even more

eagerly sought than the transmutation of metals. Life is the highest gift, and without it all other blessings turn to ashes. “All that man bath will he give for his life.” But the crowning of life is health. It is not wonderful therefore that men in all ages have sought under various names the elixir of life.

The alchemists regarded gold as the king of metals, and its symbol was the sun—the giver of light and life. When the Spaniards discovered such astonishing quantities of gold in America, they were confident that some form of the elixir of life was hidden away somewhere in the mysterious continent, and many parties were formed to explore its solitudes in quest of this great gift. For this, Ponce de Leon and his faithful band pierced the swamps of Florida, seeking “the fountain of youth,” where their leader was wounded to his death. But these were only the vanguards of a countless host that is still marching on.

The alchemists regarded gold as the most perfect form of matter; unalterable by fire, incorrodible by air, water, or any simple acid. Its very insolubility was proof of its excellence. This perfection of matter must be able to impart its properties to perishable forms of matter, and “potable gold” was supposed to be the elixir of life.

Roger Bacon was convinced that auric chloride was this elixir, and he informed Pope Nicholas IV. of the case of an old farmer in Sicily who ploughed up a golden vial containing a yellow liquid, which he swallowed supposing it to be dew, whereupon he was transformed into a vigorous youth.

Others sought the elixir as an essence derived from the distillation of a great number of substances, while the Hindoos supposed the Amreeta was obtained by churning the sea with a mountain.

We smile with superior air at such fantastic imaginings, yet not long ago the world went wild over Brown-Sequard's elixir of life,—extract of mutton.

2. *The Alcahest*.—The alchemists searched for some substance that would dissolve all other substances—alcahest, or universal solvent. Crookes forcibly suggests that this is found in fluorine.

3. *The Philosopher's Stone*, having the same purifying and ennobling office for mineral matter that the elixir of life would have on animal forms. By means of this substance they could effect the transmutation of base metals into perfect metals, “curing them of their sickness and perfecting their nature,” thus changing copper to gold and lead to silver, performing “the great work” by projection of the philosopher's stone on base metals in presence of great heat.

Such were the dreams, the hopes, and the endeavors of the alchemists—life prolonged at pleasure, health perennial, wealth beyond measure. It was a great hope, and it was slow to die. The things sought are indissolubly interlinked with the desires if not the expectations of humanity. Nothing debasing entered into this scheme, but rather the aim was to ennoble man and matter, and out of base material to bring forth the flower and fruit of perfection. To a degree, man would become a creator, and a semblance of omnipotence would be placed in the hands of mortals, not merely

¹ Abstract of an address before the Section of Chemistry of the American Association for the Advancement of Science, at Washington, D.C., Aug. 19-25, 1891, by R. C. Kedzie, vice-president of the section.

by linking himself with the powers of nature and clothing himself with their immeasurable might, but by subduing these forces and compelling them to surrender their secrets and do his bidding. By torture nature could be taught to obey, and become the slave of her mortal child, and the crucible became the instrument and symbol of this power.

If the hope of such mastery and of victory laden with so rich spoils were held out to the children of the nineteenth century would they exhibit a superiority to the visionaries of the thirteenth century? It was the gambling spirit of the olden time, and man sought to use loaded dice in his game with nature.

Consider, also, how slowly the dreams of alchemy have given place to the wide-awake facts of chemistry. The great Napoleon, during his campaign in Egypt, sought initiation into the dark mysteries of Egyptian secret art. Napoleon III., before he ascended the French throne, had in his service those who attempted the transmutation of baser metals into gold. Dumas thought gold might be an allotropic form of copper, and silver allotropic lead; and Sir Humphrey Davy told the elder D'Israeli that he did not consider the undiscovered art of transmutation an impossible thing.

About three years ago, in a neighboring city, an alchemist exhibited to a leading business man his ability to multiply gold by heating a gold coin with the philosopher's stone in a crucible, and removing from the crucible a mass of gold weighing three times as much as the original coin. Other business men witnessed a similar operation, and became so fully convinced of his power to increase the amount of gold threefold that they formed a company to multiply gold by digestion with the philosopher's stone. Gold coin to the amount of ninety thousand dollars was placed in an iron digestion vat with a quantity of the philosopher's stone. The vat was placed over a fire in a furnace built for the purpose, an iron lid placed over the vat, and securely locked, the furnace-room locked, and all the keys placed in the hands of the gold-multiplying company (unlimited), with strict orders that the vat must not be opened under three weeks. The alchemist having been called away on business to another city, and not returning at the appointed time, the gold company became suspicious and opened the vat, only to find the gold gone, and some stones and scrap iron in its place. It was the *gold* that had been transmuted.

A few months ago the same sharper was arrested in London for attempting a similar fraud, and when arraigned in the criminal court the police magistrate said "it was just possible that Pinter might have discovered some method of increasing the weight of gold." Among the victims of Pinter's philosopher's stone, a member of the house of Rothschild's and of Baring Brothers are mentioned. Who shall say that faith in "the great work" has left the earth? A few days ago at the Old Bailey he was sent to prison for swindling.

The ancients, arguing from analogy, supposed that metals grew like vegetables, only the growth was subterranean; and there was a vain search for the seeds of metals. Foiled in this quest, they thought that metals passed upward by successive development by a sort of evolution, the base metals being progressively changed to those of a higher order till perfect metal such as gold was formed. A third conception was that metals are composite, made up of some basic matter or earth, and phlogiston. The notion of the composite character of a metal was perhaps the most damaging error of the alchemists. With them a metal was not a simple body, but the union of an earth with an inflammable matter; that the

metalline character resided in the phlogiston rather than in the earth; that the greater the quantity of phlogiston combined with the earth the more perfect was the metalline character brought out, and if we could combine enough phlogiston with any earthy body we could form metals even of the most perfect character. Even Macquer, in his dictionary of chemistry (1776), is in doubt whether the kind of earth determines the character of the metal to be formed by adding phlogiston, and whether the real difficulty did not lie in securing sufficient phlogistication of intractable earths.

The perfect metal, gold, was considered to have an oily or unctuous quality, and the fact that oils contained a large amount of phlogiston was considered significant. To secure the oily quality of a perfect metal, oils were favorite sources of phlogiston; and it was claimed that if intractable earths were fused with oil in an accurately closed vessel, perfect metals could be secured. Nor was this mere theory. Beccher proposed to the States General to procure gold from any kind of sand, and claimed to demonstrate the same by his famous experiment of *Minera arenaria perpetua*, building his house on the sand very literally. So Beccher and Geoffroy proposed to obtain iron from all clays by heating them with linseed oil in close vessels.

The alchemists reasoned that if phlogiston were accepted as the metalliferous principle, the combination of which with any earth would convert it into a metal, and the escape of which would reduce any metal to an earth, then the transmutation of one metal into another metal would seem no more difficult than the transformation of earths into metals.

The phlogistic theory of Beccher and Stahl was considered a great advance in its day because it enabled the chemist to classify all the then known facts of chemistry. But it soon became a bar to scientific progress, and with its overthrow a new era dawned in science.

The change of a metal into another metal was not a mere theory with the alchemists, they saw repeated proofs of this transmutation. By the purifying influence of fire they made purest silver out of unquestionable lead, and the silver medals attesting this fact which Dr. Bolton lately found in Austria were the *ecce signum* of the alchemists. The Chinese still hold that lead kept in fusion for two hundred years becomes silver, and silver similarly treated changes to gold. What the alchemists required was some means to quickly transmute the whole of the lead into silver and prevent the large loss of lead when fire alone was used. The truth wrongly interpreted only led them widely astray.

The conception also of the instability of the properties of matter — that, for example, color, lustre, weight, malleability, fixedness in the fire, etc., are properties that may be imparted to a body destitute of them, irrespective of the nature of such body, just as a man may change his clothes without changing his person — was most misleading for the alchemists. "If the property is separate from the substance, like our apparel, let us clothe copper with the properties of gold and thus make it gold." The theory of the instability of matter was the quicksand that swallowed up scientific progress for the alchemists.

The indestructibility of matter, and the possibility of recovering a given substance notwithstanding all its disguises by combination with other bodies, — the persistence of matter and the immanence of its properties, — were grand discoveries in material science. They marked the transition from alchemy to chemistry. The recognition of the indestructibility of force was the second great step, the crowning discovery of modern physics. In the words of Faraday, "It is the

highest law in physical science which our faculties permit us to perceive."

Shall we take a third step and proclaim the permanence of force but the destructibility of matter,—that the atom may have a life, grow old, and die, or pass back into primitive no-thing-ness, or become the ether of which we talk so much and know so little? Shall we assume that radiant force may be changed into matter and fall under the law of gravitation?

No single thought has contributed so much to give form and permanence to chemical science as the atom of Dalton. An atomic theory was indeed held by the Greeks in regard to the constitution of matter, but it related chiefly to the question of the continuity or discontinuity of matter in mass, and considered the question of the limited or unlimited divisibility of matter. But the chemical atom, with its application in explaining the law of definite and of multiple proportions by weight in chemical combinations, was the gift of the Quaker schoolmaster of Birmingham. It has furnished not merely a basis for nomenclature and notation, but has given form and substance to chemical science. Like a sentinel rock, it lifts its immovable form amid the shifting waves and tides of chemical theories. Shall the chemical atom finally be relegated to the limbo of exploded theories and creeds outgrown? The question is perhaps nearer our doors than we had suspected.

The question has been seriously raised by an eminent American chemist whether gold can be manufactured. On the affirmative side of this question he points to the fact that didymium has been split into two metals, and by recombining these two new metals the old didymium was again formed. He also points out the complex nature of yttrium as shown by Crookes by means of the spectroscope, and then proceeds to say: "These facts, and many others that could be given, make it probable that the so-called chemical elements are not really elements, but compounds, which in time we shall be able to separate into their constituents, and conversely to reproduce by combining other substances. Among the heavy elements—and hence those that would be expected to yield to the searching attacks of the chemist—is gold. It is not improbable that in time it will become possible to make gold in large quantities—an event which would throw it out of use as a standard of value, so far as it derives its own value from its rarity" (North American Review, Sept., 1890, p. 377).

At first sight this might appear to be a chemical canard, but the writer proceeds to point out the social and financial results of cheapening of gold.

The statement that didymium is a compound metal is of great interest to the chemist. But the fact that the reunion of these metals will form the old metal or alloy is not so surprising, but is what any chemist would expect. But how do such facts show the probability or even possibility of making any given metal out of heterogeneous materials? If the combination of cerium and samarium would form didymium then a plausible case would be made out. But if praseodymium and neodymium are required to make didymium, how are we nearer the manufacture of this last metal by such discovery? We must still have the two new metals to make the old metal. Suppose that gold can be split into two or ten new metals, the reunion of which will form gold, does this bring us one whit nearer the new age of gold? If it takes gold to make gold, what part or lot have baser metals in such transformations?

The trend of recent discoveries is to increase the number

of simple or elementary substances. The simple nature of any substance has only been held provisionally, regarded as elementary until its compound nature is shown by exhibiting the separate elements of which it is composed. The more recendite the appliances for investigation, the more complete the differentiation of matter, the greater will be the number of elementary substances, and yet we will be as far as ever from the ability to change one metal to another.

The question of the primary and essential nature of matter belongs to metaphysics rather than physics. Yet the nature of matter as well as its properties is a vital question in chemistry. The chemist has made certain basic propositions the foundation of his science. The essential immutability of matter is a corner-stone. Weight and measure have no place in a science that deals with matter essentially variable in its nature, but it is weight and measure that have made chemistry the most exact of all natural sciences.

The idea of an original simple matter as the basis from which all things have been formed is not wholly modern. Duns Scotus advanced the idea that the basis of universal existence was a *materia primo-prima*, by the differentiation of which the individual is formed. About twenty-five years ago a modified form of this theory was brought forward by Professor Hinrichs of Iowa, who advanced his theory of "pantogen" or "urstoff" to explain the constitution of matter. There was only one simple or elementary matter, urstoff; and as all forms of matter are produced from this primary matter, he called it "pantogen," and the products formed by the reduplication of this simple matter he called "panatoms." His argument was based upon a parallelism between astronomy and chemistry: "The basis of this celestial mechanics (astronomy) is only a hypothesis, that of universal gravitation, which essentially consists in the affirmation that the heavenly bodies only differ in regard to the amount or quantity of matter. Let us have the boldness to pronounce a similar hypothesis in regard to chemical atoms. Let us suppose that the atoms of the different elements only differ in regard to quantity, that is, in regard to the number and relative position of the atoms of some one primary matter, just as the planets only differ according to the number of kilograms of ponderable matter they contain and its distribution around their axes. Since everything would be composed of this one primary matter we call it pantogen, and its atoms panatoms."

This programme of atomechanics was caustically reviewed in the *Chemical News*, December, 1867, which pointed out the fact that Professor Hinrichs, like all discoverers of his class, continually falls back on analogy. "This too free use of analogy has been the bane of science from the time of Plato, and it would appear that the race of speculators who mistake fanciful analogies for fundamental scientific laws is by no means yet extinct."

The reviewer closes by urging Professor Hinrichs, as the crowning feat of his discovery, and that which would compel the adhesion of scientific men to the new theory, "to isolate pantogen." Has the whirligig of time brought the keen editor and sharp reviewer around to face urstoff and panatoms?

How was the atom formed? Was it coeval with matter, or did matter antedate the atom? Was there *prima materia*—pantogen, protyle, urstoff—out of which the atom was formed by reduplication of urstoff upon itself? Do heredity, selection, environment, and discriminative destruction explain atomic formation, and the discrimination of atom from atom in the domain of chemistry? "A theory of evolution

of this kind," says Clerk Maxwell, "cannot be applied to the case of molecules, for the individual molecules neither are born nor die; they have neither parents nor offspring; and so far from being modified by their environment, we find that two molecules of the same kind, say of hydrogen, have the same properties, though one has been compounded with carbon and buried in the earth as coal for untold ages, while the other has been occluded in the iron of a meteorite, and after unknown wanderings in the heavens has at last fallen into the hands of some terrestrial chemist."

When we attempt to apply the process of discriminative destruction the trouble increases, for "we should have to account for the disappearance of all the molecules which did not fall under one of the very limited number of kinds known to us; and to get rid of a number of indestructible bodies exceeding by far the number of the molecules of all the recognized kinds, would be one of the severest labors ever proposed to a cosmogonist." The "missing links" would form the principal chain.

But Mr. Crookes finds, by means of an interpretative illustration of the periodic law, an explanation of the formation of matter out of protyle with segregation into atoms of definite valence and proximate molecular weight.

The discovery of the periodic law of chemical elements was a long stride in scientific progress. It bids fair to be as masterful in chemistry as universal gravitation in astronomy, and a certain analogy may be traced between them. The planets have certain orbits around the sun, and velocities of revolution proportional to their mass. Did position fix their mass, or mass determine their position? By the periodic law, the atom having a certain mass or weight falls into a certain position. Is the mass of an atom determined by its position, and not rather the position determined by its mass? Does the periodic law require us to consider the properties of matter as mathematical functions of numbers, and thus reproduce the Pythagorean philosophy of number and harmony, that "all things are number, and that number is the essence of everything—the elements of numbers are the elements of existence." Or have position and force acquired the properties of matter?

If there was ever a flank movement on Nature by which she has been compelled to surrender a part of her secrets it was the discovery of the spectroscope, "which enables us to peer into the very heart of nature." It is the "Open sesame" of physics and chemistry. If biology could lay its hands on a similar instrument to unlock the secrets of life, what fields of discovery would unfold before the explorer!

By means of the spectroscope we may question the very elements and submit them to cross-examination in the court of science. Surprising results have thus been reached, but the trend seems to be all in one direction, to show the complex nature of what was supposed to be simple matter, that didymium, e.g., was not a simple body, but contained at least two metals, was twin in more senses than one. It was much the same as Davy's showing that potash was not a simple body, anomalous among chemical substances, but contained a metal, and thus fell into line in chemical combinations. But does the discovery of even a nest full of metals where only yttrium was supposed to be require the assumption of meta-metals, stuff which has not yet grown to the full measure of a metal; shall we suppose that each *ultissimum elementum* has only one line in the spectrum, and that the spectroscope will yet reveal swarms of meta-metals in the chemical system, just as the telescope calls out the countless stars from the Milky Way?

On the other hand, does the splitting up of the rare metals justify the assumption that the metals most fixed in character, and which show no tendency to split into meta-metals, such as gold and platinum, are compound in constitution and may be compounded out of baser materials? Crookes's suggestion that what comes to us as copper has been shunted on to the wrong track in its passage from aboriginal elemental matter to make gold, holds out small hope to metallic transmutation.

In the use of the scientific imagination few men can compare with the editor of the *Chemical News*. Let us briefly follow Mr. Crookes in his scheme of the genesis of the elements out of ante-elemental material,—protyle, urstoff, im-material matter, out of which matter may be formed by a process of condensation through the cooling down of the original fire-mist until it acquires elemental properties. By a process of polymerization of protyle, or reduplication of dissociated matter, with fall of temperature and acquisition of different amounts of electricity, he supposes the elements are evolved as known to us. Assuming the periodic law of Newlands and Mendeleeff, he pictures to the mind how the elements may have been formed out of matter in the ultra-gaseous condition by cooling down below the temperature of elemental dissociation, when out of the swarming myriads of ultra-elemental matter the elements may group into knots at nodal points. Around a central line, electrically, magnetically, and chemically neutral, the length of the line marking the fall of cosmic temperature, the mighty gravitational force swings like a pendulum, but with lemniscate motion through space of three dimensions, and thus the atoms are formed and the elements appear, from hydrogen to uranium. The outward swing gives the electro-positive elements; the inward swing forms the electro-negative, the degree of electrization determines the atomicity, and the position on the left or right of the neutral line determines the magnetic quality—paramagnetic or diamagnetic.

Such a scheme of the genesis of the elements fires the imagination with the loftiest conceptions, so many things fall into line and order. The very hiding place of missing elements seems to be pointed out, and newly discovered metals fall into their fore-ordained place prepared for them before the foundation of the worlds. It would seem presumptuous to question a theory so beautiful and satisfying, but its foundations are assumptions of a sweeping character. If we concede the existence of matter without the properties of matter, we have yet to learn how it can acquire the properties of matter. If we concede that it is ultra-material because of heat, how can it part with heat before it acquires radiant power, a property of matter? We might also be tempted to inquire, what has become of the heat which once held the universe in the ultra gaseous condition?

Nor is the theory of the successive formation of elementary atoms, with their progressive increase of atomic weight by reason of the fall of temperature below the point of elemental dissociation, entirely satisfactory. It is claimed that hydrogen and then lithium first appear in the elemental condensation, because with them the diminution of temperature at which elemental dissociation ceases is reached first of all, the heat being still too great for other bodies to exist even as elements. The heavy metals, such as platinum and gold, with large atomic weight, are formed later in time, because a vast reduction of cosmic heat was necessary before dissociation would cease and elemental consociation become possible. Do platinum and gold give indications of a tendency to dissociation more marked than that of lithium when questioned

by heat, electricity, and chemical action, or even when cross-examined by the spectroscope? Does not gold exhibit an integrity worthy of a noble nature? Does it hold out to alchemy the most distant hint of a multiple nature by means of which she may hope to divide and conquer?

The hypothesis of the evolution of the chemical atoms by aggregation or polymerization of one matter substance challenges scientific thought. Based upon broad assumptions and sustained entirely by analogy, it will hardly disturb the relative coinage value of the metals by holding out hopes of alchemic transmutation. The advice of Mr. Crookes to treat it simply as a provisional hypothesis is conservative and wise.

NOTES AND NEWS.

TO MEET the desire for instruction in the modern branches of astronomy, which have been so wonderfully developed in the last few years, a post-graduate course in astronomy and astro-physics, open to a limited number of students, has been established at the Western University of Pennsylvania. Exceptional facilities for such a course are afforded by the library and apparatus of the Allegheny observatory. Instruction will be given by means of lectures, recitations, and examinations, and by the practical use of instruments in observation and measurement. A knowledge of mathematics equivalent to that given in the undergraduate department of the university is requisite for admission to the course, which will extend over a term of two years. Further information may be had of Dr. W. J. Holland, chancellor of the university, or of Professor J. E. Keeler, director of the Allegheny observatory.

— At Hanover, Penn., a system is used for cooling water, that is both simple and beneficial, according to a description of it in the *Railroad and Engineering Journal*. The town is described as being closely built, and without any system of drainage, so that the water in the wells is unfit to drink. Some years ago these reasons led to the introduction of a supply of very excellent water from a large spring about three miles distant. This water is brought through iron pipes, and when it reaches the consumer in summer is warm, while the water in the wells is cool. For this reason many of the inhabitants drink the well-water, and, as a consequence, typhoid fever is a prevalent disease in that community. In order to obtain pure cool water, not impregnated with lime, some of the inhabitants of the place have adopted a plan which is so simple and gives such excellent results that it is worthy of general adoption wherever there is a water supply other than wells or springs. The plan is as follows. A cylindrical galvanized sheet-iron tank twelve inches in diameter and four or five feet long, is placed in the bottom of a well. The tank is then connected by a galvanized iron pipe with the water-supply pipes, and another pipe is carried from the tank to the surface of the ground, or to any convenient point for drawing water, and has a cock at the upper end. The tank is consequently always filled with water from the water-supply, and being in the bottom of the well, the water is cooled off and acquires the temperature of the well, so that that which is drawn from the tank is as cool as well-water, and is without any of the impurities with which the latter is contaminated. The water drawn from the tank in one of the wells in the place named had a temperature of 56° when the thermometer in the atmosphere above stood 76°. This method gives an abundant supply of cool water during the whole summer, and can be adopted in all cities, towns, or in the country. If a well is available, it can be used; if not, by simply digging a hole in the ground deep enough so as not to be affected by the surface temperature, and burying the tank, it will answer equally well. This hole might be dug in a cellar or outside the building. If the water has any impurities in suspension, such as mud, the tank should be made accessible, so that it can be cleaned separately.

— A writer in the *Illustrated American* says that in work which requires the application of great strength combined with good judgment the elephant is supreme; but as a mere puller and

hauler he is not of great value. In piling logs, for example, the creature soon learns the exact manner of arranging them, and will place them upon each other with a regularity not to be excelled by a human workman. Sir Emerson Tennent, in his work on Ceylon, mentions a pair of elephants who used to raise their wood-piles to a great height by rolling the logs up an inclined plane of sloping beams. The same writer was once riding near Kandy, toward the scene of the massacre of Major Davies' party in 1803. He heard a queer sound in the jungle, like the repetition, in a hoarse and discontented tone, of the ejaculation of "Urmph, urmph!" Presently a tame elephant hove in sight, unaccompanied by any attendant. He was laboring painfully to carry a heavy beam of timber which he balanced across his tusks, but, the pathway being narrow, he had to keep his head bent in a very uncomfortable posture to permit the burden to pass endways, and the exertion and inconvenience combined led him to utter the dissatisfied noise which had frightened the horse. When the creature saw the horse and rider halt, he raised his head, reconnoitered them for a moment, and then he flung down the timber, thoroughly appreciating the situation, and pushed himself backward among the bushwood so as to leave a passage for the horse. But as the horse did not avail itself of the path, the elephant impatiently thrust himself deeper into the jungle, repeating his cry of "Urmph!" but in a voice meant to invite and encourage. Still the horse trembled, and the rider, anxious to observe the instinct of the two intelligent creatures, forbore any interference with them. Again the elephant wedged himself farther in among the trees and waited for the horse to pass, and after the horse had done so timidly and tremblingly, the wise creature stooped, took up his heavy burden, and, balancing it on his tusks, resumed his route, hoarsely snorting his discontented grunt as before.

— Experiments in seeding with different quantities of wheat were begun on the farm belonging to the Ohio State University several years previous to the establishment of the experiment station. These experiments have been continued on the same farm by the station, and the tenth experiment has just been harvested. In this experiment two varieties of wheat were used, Dietz and velvet chaff (Penquite's velvet). The land on which they were sown had borne nine successive crops of wheat, having been dressed three times with barnyard manure during that period. The land occupied by the velvet wheat lies upon a gravel knoll, sloping to the west, the gravel coming in some places to within two or three feet of the surface. The wheat on this knoll has for several seasons been less vigorous than in other parts of the field, and this season especially it was badly infested with the wheat midge, commonly known as the red weevil. The Dietz wheat grew upon land of a little better quality, and sloping to the east instead of the west. It was but slightly injured by insects. While the yields of the velvet are irregular, they do not favor very thin seeding. In the case of the Dietz, however, the results are decisive. Every time the seed falls below four pecks or rises above seven there is a falling off in yield. In the long run, seeding at from five to seven pecks has given a larger harvest than when less or more seed was used.

— The idea of university extension had its first expression at Oxford as far back as 1845. Since then its advance has been constant and of late years very rapid. Though Oxford was the first university to give a form to the wide-spread desire for higher education, it was almost the last to enter upon the practical details of the work. That it now has by far the larger number of extension students is due in great measure to the energy and skill of Michael E. Sadler, secretary to the Oxford Delegacy, who, in the current number of *University Extension*, discusses the future of this movement in England. Other articles show the relation of this work to the common school teacher and to American women. One of the most successful experiments of last season in extension teaching was at Providence in connection with Brown University, and is described in this August issue by Professor Appleton of that faculty. In the department of Notes is an interesting hint as to the natural connection of this movement with the Chautauquan system, so excellently developed by Bishop Vincent and his assistants.

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Attention is called to the "Wants" column. All are invited to use it in soliciting information or seeking new positions. The name and address of applicants should be given in full, so that answers will go direct to them. The "Exchange" column is likewise open.

THE NATURAL HISTORY OF ANALOGY.¹

By the natural history of analogy is meant the treatment according to the methods of natural science of a type of mental action interesting at once as a psychological process, and again from its practical results as a factor in the anthropological history of the race. While logically an analogy may be defined as an inference of a further degree of resemblance from a given degree of resemblance, it would be well to include in the present survey types of argument diverging somewhat from the standard. It should also be borne in mind that these reasonings may be unconsciously conducted without analysis, and yet be communicable from mind to mind, and influential in the fixation of belief and the guidance of conduct.

It will appear that the progress from the attitude of the savage to that of the civilized man with respect to the understanding of the natural and physical world, may, to a considerable extent, be regarded as a shifting of the position occupied by the argument by analogy. It would appear, too, that this form of argument, used by the scientist of to-day only with the greatest caution, is a predominant one in more primitive forms of thought. For example of such arguments we turn to three departments of mental action, closely related to one another, and each contributing to the value of the general results. We look first amongst the customs and beliefs of primitive people, then amongst the doings and sayings of children, and thirdly amongst that very extensive class of superstitions and folk-lore customs which no nation, however high or low in the scale of civilization, is without. The Zulu chewing a bit of wood to soften the heart of the man he wants to buy oxen from, the Illinois Indian stabbing the figures of those whose days they desire to shorten, the operation upon a lock of hair or the parings of the finger-nails, together with the endless forms

of primitive witchcraft, rest upon the notion that one kind of connection will bring with it others. The same idea underlies the customs directing and prohibiting the use of certain food. The Malays eat tiger to acquire the cunning of that animal, the Dyaks refuse to eat deer for fear of becoming faint-hearted, and in the Mexican rite called the "eating of the god" is found an elaborated form of the same belief.

The interpretation of omens among primitive people also proceeds by analogy, the relation between omen and issue being guided by a sense of analogical fitness. To determine whether war is to be upheld or let fall, a stick is set in a bowl of rice, and if it stand the war is continued, and if it fall the war is let fall also. A somewhat less direct form of analogy appears in customs relating to images and names. The name becomes an essential part of the thing, and thus what is done to the name will affect the thing; hence the origin of the taboo, changing of the name in case of sickness, and the like. Even vaguer and more general principles of analogy may underlie important customs, such as that things go by contraries, for example, or that to produce unusual effects, drastic means and rare substances must be employed. The bizarre fancies, the grotesque performances, and the uncanny pharmacopœia of the medicine-men in part derive their character from this source. All these are but partial illustrations of the savage's fondness for the use of arguments by analogy and the naturalness with which he observes and assimilates all phenomena according to this habit.

The study of children reveals evidence of similar arguments, although the earnestness of the belief cannot be so readily tested. Moreover, we have no good collection of children's sayings and doings for such examples. In spite of this, however, their fondness for analogical arguments may be regarded as an additional point of resemblance connecting the infancy of the individual with that of the race.

The superstitions current among us — survivals from a culture which they are of to a culture which they are in — abound in instances of analogy, simple and complex. Especially fertile fields for such instances are the beliefs concerning dream-interpretation, those underlying the practices of folk-medicine, those connected with names and numbers, and, in more systematized form, the doctrine of sympathy, and signatures of astrology and kindred sciences. The modern cheap dreambook is full of quaint arguments by analogy. When it tells us that to dream of gloom means imprisonment, that the pine-apple in dreams is the omen of crosses and troubles, that to dream "of being mounted on stilts denotes that you are puffed up with vain pride," to dream of onions indicates the betrayal of secrets, to dream "of a dairy showeth the dreamer to be of a milksop nature," and that a zebra indicates a checkered life, — we see what various and peculiar results may be reached by such logic. The many customs and superstitions connected with such numbers as three, seven, and thirteen need but be referred to to show how thoroughly this variety of thought-habits is permeated with the argument by analogy.

The remedies of folk-medicine easily reveal the analogies through which they originated. The connection of toads with warts is due to nothing more than the warty appearance of the toad's skin; the snail is used for ear-ache because of the many snail-like passages in the ear, red things are used for fevers, yellow things for liver complaints, and many of the peculiar and disgusting remedies of our forefathers clearly imply that out-of-the-way substances must have special efficacy.

¹ Abstract of an address before the Section of Anthropology of the American Association for the Advancement of Science, at Washington, D.C., Aug. 19-25, 1891, by Joseph Jastrow, vice-president of the section.

The doctrine of signatures depends on the notion that the appearance of plants signify their use. The eye-bright, on account of the eye-like spot in its corolla, is used for eyes; the granulated roots of the saxifrage indicate its use for calculous complaints; the human shape of the roots of ginseng give it special efficacy; and the walnut, the parts of which so closely resemble the skull and brain, is marked out for the mental diseases. The doctrine of sympathies has appeared under various forms, and has quite an important history. The common phrase, "Take a hair of the dog that bit you," is a survival of this system, and shows that the logic underlying it is nothing more than that two phenomena once connected, either by coincidence or as cause and effect, will continue to maintain this connection. Paracelsus describes a peculiarly composed weapon-salve which was to be applied to the weapon that caused the wound and thus heal the wound. Sir Kenelm Digby's practices involve the same notion. He procured a handkerchief or other personal belonging of the patient, and when this was dipped in water, the fever abated, and the like. The sympathetic alphabet was another form of this doctrine. Two friends each cut a piece of skin and grafted it on the skin of the other; on this was tattooed an alphabet, and communication was established by the belief that pricking a letter on the skin of the one friend would cause a pain in the corresponding place of the other. Even in the present century two Frenchmen announced the discovery of a species of snails which, however widely separated, would go through the same movements, so that if the one is guided over an alphabet the other will rest upon the same letters.

The most systematic of all these pseudo-sciences is astrology, the analogies underlying which being of all grades of remoteness. The system of correspondences which it proposed gave unusual opportunity for flights of imagination, and no analogy, however far-fetched, was too slight for the foundation of some doctrine. The accident by which the planets were given the names of deities was sufficient to connect the characters of those deities with the lives of persons at whose births these planets presented especial relations. Similarly the fact that constellations were named by fancied resemblances to certain animals was sufficient to connect one's career with the qualities of that animal; thus a child born under the sign of a lion would be courageous, but one born under the crab would not go forward in life.

Amongst the various generalizations upon which these considerations have bearing, attention will be called to the following. The history of the argument by analogy adds another link to the chain of evidence by which the development of the individual is connected with that of the race. We trace similar appearances amongst savages, amongst children, and still more strikingly in those surviving forms of superstition and pseudo-scientific systems which we are warranted in regarding as reversions to more primitive types of thought. Again, the principle that what was once the serious business of adults serves in more advanced stages of culture for the play of children or the amusement of leisure hours, finds illustration here. Just as the drum, once the terrifying instrument of the warrior, or the rattle, once the potent implement of the medicine-man, has become the toy of children, or as the bow and arrow are maintained for sport only, so the outgrown forms of thought, the analogies, that were serious to our ancestors, now find application in riddles and puns. When we ask, "Why is this one object like another?" we are asking for just such out-of-the-way resemblances as have been noted above. And, finally, in a

variety of ways, the consideration of the argument by analogy adds to our appreciation of the unfoldment of mental powers, of the slow and painful steps by which the tenets of modern science have been gained, of the necessity for continued striving in this direction, as well as of the underlying unity of movement and design by which these phenomena acquire their deeper and more human interest.

THE ETHER.¹

It was with some fear and trembling that I selected as the subject of a brief address a subject of such vast dimensions, and the feeling increased as it became more and more evident how difficult it is to give clear expression to ideas that are very far from clear.

In former days many reasons were given showing the necessity for the existence of an ether which do not seem conclusive now. We can scarcely appreciate the bearing of an argument to the effect that there must be an ether or nature would be disgusted with the major portion of space. We should begin at once to wonder what there could have been in the experience or training of any person that could lead him to such a conclusion. We do not see the need of an ether to hold up the stars and planets and prevent them from falling to the ground. We do not try to explain by similar means how the planets are kept in motion.

We do, however, have other needs for ether, which seem important and pressing; still we cannot help wondering occasionally, with Theophrastus Such, what kind of hornpipe we are dancing now. How will our ideas commend themselves to those who follow?

For many years it was taught that the luminiferous ether was an incompressible jelly-like mass, and that light is an elastic pulsation in this medium. The elastic theory, however, was burdened with serious difficulty. No phenomena corresponding to a vibration normal to the wave front could be found, but mathematical analysis showed that such waves should in general exist in an elastic medium. Green saw that this wave would produce no optical phenomena if the velocity were either zero or infinite, and concluded that it could not be zero in a stable medium. Those who followed him in time also accepted his conclusion that the ether was incompressible, and that the compression-rarefaction wave must travel with an infinite speed. So the matter stood until 1865, when Maxwell proposed an electro-magnetic theory of light. According to this theory of light no compression-rarefaction wave should exist, and light was conceived to consist of local electrical displacement in a plane at right-angles to the line of propagation.

The rival theory met with great favor. It gradually became clear that Maxwell's theory of light was attended with less difficulty than the elastic theory. Twenty-three years later, Sir William Thomson brings a powerful reinforcement to the elastic theory which changes the whole aspect of the case. He simply suggests that the compression-rarefaction wave could properly and logically be gotten rid of in the elastic theory by making its velocity zero, instead of infinite, as Green had done half a century before. What Thomson did was to examine anew the ground upon which Green had concluded that a zero velocity for the compression wave involved an unstable state of the medium, and it was found that such a conclusion did not follow.

¹ Abstract of an address before the Section of Physics of the American Association for the Advancement of Science, at Washington, D.C., Aug. 19-25, 1891, by Francis E. Nipher, vice-president of the section.

And it is worthy of remark, as a matter of congratulation, showing how far scientific men have emerged from the intellectual pugilism of the last century, that this audacious departure was met with pleased surprise, instead of angry polemics against a new heresy.

The modern theory of the ether took its origin with the undulatory theory of light. It had for a tangible basis the observed fact that light requires time for transmission. Whether measured over long distances through interplanetary spaces, or through short distances on the surface of the earth, the time required for transmission is proportionate to the distance. It was to such facts that men finally came to look for a justification of the assumption of an all-pervading medium. The modern theories of the nature of the ether are based wholly on the results which must be produced by this invisible machinery, instead of upon an assumed dictum that Nature abhors a vacuum. Perhaps no teaching of science is now more firmly established than the doctrine of the existence of an ether, and that it is capable of transmitting energy by virtue of peculiarities which must be as definite as those which characterize a train of cog-wheels.

But when one comes to assemble all of the results which remain to be accounted for and explained, it becomes exceedingly difficult to construct a mental image, in three-dimensional space, of the machinery capable of producing them all.

Green's idea of the ether makes it an incompressible, frictionless, structureless jelly, sometimes called a "solid," which opens out and allows the particles of ordinary matter to sweep through without appreciable resistance. Thomas Young likened the operation to the sweeping of the wind through the leaves and branches of a forest. Certain well-known electrical experiments of Faraday and Cavendish seem to require the assumption that electricity is, or is some function of, an incompressible medium. On the other hand, the slowing up of light in space occupied by matter indicates that the ether within must be either more dense (as Fresnel believed) or less elastic than that existing in free space. It is certainly very difficult to understand what there can be in the molecules of matter which can increase the density of an incompressible medium, as the experiments of Fresnel seemed to require; nor is it as yet easy on any hypothesis to account for those condensed films of bound ether which are carried along with the particles of moving matter. They seem to be differentiated with equal sharpness from the free ether which sweeps through matter, and from the spinning aggregation of other vortices which Thomson assumes may perhaps make up the molecule or the atom. Certainly it would seem that a vortex ring in a medium so devoid of friction that these vortices are permanent, could hardly drag along with it portions of the surrounding medium, from which the analysis of Helmholtz shows it must be wholly and forever differentiated. And the matter is not simplified by the beautiful experiment of Michelson and Morley. It appears that the frictionless ether adheres in a layer around the earth as a whole, or at least that it was entangled in and carried along with the matter composing the building in which their experiments were made.

If, however, one forms a Torricellian vacuum in a barometer tube of either transparent or opaque material, it is easily and completely shown, by an inclination of the tube, that the ether flows freely through matter. Whether the ether be incompressible or highly compressible, it seems to be as impossible to compress it in a chamber surrounded by matter as it would be to compress water or air in a fisher's net.

The fact that a rotational phenomenon, such as must exist in the field of a steel magnet, is maintained indefinitely without the expenditure of energy, must certainly justify the assumption that the ether is frictionless, that the ether-vortex atom is a possibility.

The effects which seem to be nearest to a mechanical explanation are those which result in heat or light and electrical and magnetic induction. It is possible to construct machinery which will represent the conditions for propagation of a magnetic induction in a plane radial to a conducting wire. A train of cog-wheels separated by elastic idle-wheels which articulate with them, or a series of smooth rimmed fly wheels connected by elastic bands, will do the work. It becomes more difficult when we spread this paraphernalia into three-dimensional space.

No one, of course, thinks of the geared ether models of Maxwell and Fitzgerald as anything more than an aid to a conception of the nature of the action to be explained. When we come down to the working drawings we find great room for conjecture, and some demand for invention. Do the particular cog-wheels which slip on each other without friction at the surface and within the body of a perfect conductor ever get outside of the body into free space where they must gear rigidly with each other? If so, why do they behave so differently in the two places? What happens to this gearing when masses of matter which it permeates are set into rotation? Is there any difference between the earth's magnetism and the motion of masses of ether at the earth's surface? It is exceedingly difficult to understand how a frictionless medium in which a magnetic spin is permanent, can offer resistance to shear, unless the rigidity involved is due to motion.

Another function which the ether should perform is the transmission of gravitation. The theory which has attracted most attention, the only one suggested which has been seriously considered, is the one first announced by La Sage of Geneva, and elaborated by Preston and others. It seems to require that the ether shall partake of the nature of the gas, the mean free path being of interplanetary dimensions.

Such a medium it is not difficult to admit as a possibility. The theory accounts for the gravitation of bodies towards each other as due to the difference in the bombardment of bodies on the exposed and sheltered sides. Each body shields the other, so that gravitating bodies are pushed together. It is, however, necessary that the particles at the centre of the earth shall have the same resultant differential pressure directly exerted upon them, causing them to gravitate towards the sun, as if the surrounding mass of the earth were removed. It is, in fact, necessary to assume that nearly all the ether particles which plunge into the earth's figure pass straight through the earth without encounter with matter.

It is, however, of some interest to know quantitatively about what velocities must be involved in such an impact theory of gravitation. DeVolson Wood has made a computation of the density of an elastic medium capable of transmitting a pulsation with the velocity of light, and of transmitting from the sun to the earth 2.8 calories per minute per square centimetre of surface. While it seems to me that some fault may be found with his analysis, still the results reached by him seem to be of the proper order of magnitude.

The density of the ether turns out to be about $\frac{2}{10^{24}}$ pounds per cubic foot, so that a mass equal in volume to that of the earth would contain about a pound and seven-tenths. This value for density lies well within the limits which Sir William Thomson assigned to the same quantity.

Suppose a stream of ether of such material should sweep radially sunward, its particles colliding in unelastic impact with the earth, what velocity must be given to this current in order that the earth might be kept in its present orbit? The velocity turns out to be eight millions of times the velocity of light. The mass of ether colliding per second would be 14,000 tons, which is equal to the mass of a sphere of water having a radius of about fifty feet.

But in LeSage's hypothesis the ether particles do not move in parallel stream-lines. They plunge into the earth on all sides, the sheltering effect of each gravitating body upon the other being the cause of gravitation. But this sheltering effect is very small, by reason of the open structure that matter must be assumed to have in order that the interior particles of large masses may be accessible to direct impact. It follows that the percentage of particles really effective in producing gravitation must be very small; likewise that the individual particle velocities must enormously exceed the velocity computed for a stream of ether sweeping radially sunward and capable of holding the earth in its orbit.

It is unphilosophical to condemn the theory of LeSage because it requires us to deal with such immense velocities. Any theory of gravitation must involve something unusual, and it was pointed out by Laplace that the velocity of gravitation must enormously exceed that of light. But there are other difficulties.

The rebound of the particles must be a perfectly elastic collision; otherwise the bombarded body will rise in temperature. By reason of the open structure assumed and necessary, in order that the effective surface may be proportional to mass, the exterior figure is of no importance. For simplicity of conception, if we assume a solitary sphere, in space, it will be symmetrically beaten from all sides. The particles which pass straight through, without deflection or elastic rebound, will be symmetrical all around, as will likewise the few which suffer reflection. A second body now appearing in its field will shield the first by deflecting particles which would otherwise strike it, but will reflect to the body an equal number which would otherwise not strike it, the latter group having the same average momentum as the former.

Sir William Thomson has suggested that the difficulty may be avoided by assuming that the collision is not a perfectly elastic one, and that the rise in temperature may be prevented by rotation of the colliding particles. This might be true of the ether particles, but there is the best of reason for believing that there is no molecular rotation in solid bodies.

It seems probable, therefore, that a rebound sufficiently unelastic to account for gravitation must result in a rise of temperature, which can scarcely be admitted. The theory has, however, been defended with great skill by Preston, who has attempted to show that such a medium may even produce the transverse vibrations of light. The objection that gravitation must travel at enormously greater speed than light he tries to meet by the hypothesis that the gaseous ether may have two groups of particles, one much larger than the other. The properties of the luminiferous ether have, however, been so well worked out in the last four or five years, that it seems hardly probable that the gaseous ether can be admitted as the medium which transmits light. Whether gravitation can or cannot be explained in some such way as LeSage suggested, it seems worthy of question whether the gravitation medium can be ether which transmits radiant energy with a velocity of 300,000,000 of metres per second.

Sir William Thomson's last word on the elastic solid theory of ether, according to which the compression wave is impossible by reason of a property which is imparted to the medium, seems to cut off the last hope that the elastic solid luminiferous ether can be concerned in gravitation. The electric theory of light does not require Sir William Thomson's limitation to be put upon the medium. According to this theory the medium may be incompressible, and there is strong reason to believe that it is practically so. As Willard Gibbs has pointed out, the two theories seem to be practically on the same footing, if the third wave is given an infinite velocity in the electric theory, and zero velocity in the elastic solid theory.

There are other points concerning the action of matter upon the ether which are perhaps in a fair way to receive a clearer solution. The observed fact that light travels in water with a speed of about three-fourths of what it has in air, apparently means that the transmitting medium is either more dense or less rigid in water than in air. Fresnel's hypothesis is that its rigidity is the same in the two media. His formula, as developed by Eisenlohr, for the relative motion of ether and matter which it permeates, when the matter is set into motion, assumes, clearly and baldly, that the ether is more dense inside of matter than in free space. The amount of ether occupying a volume of one cubic centimetre will condense to nine-sixteenths of a centimetre on passing into water. It is compressed until its density is nearly double. To be more accurate, its density increases by seven-ninths of itself upon passing into water. Of course this is to be regarded as a mathematical fiction serving to bridge over a gap in our knowledge of the physics of the ether. Certainly a medium behaving in this manner would not be considered to be a shining success as an incompressible medium. Fresnel's conclusion rests mainly on an experiment first made by him and repeated with great success in an improved form by Michelson and Morley. This experiment was to determine the effect of moving water upon the velocity of light transmitted along its stream-lines. The result reached was that the resultant velocity of light is its velocity in the quiescent liquid plus or minus seven-sixteenths of the velocity of the moving liquid.

The velocity of the water current was varied between 8.72 metres and 5.67 metres per second, in Michelson and Morley's experiment. A series was made with an intermediate velocity of 7.65 metres per second. The weights of the three determinations are quite different, and it appears to be still an open question whether the result obtained is independent of the velocity of the water. In Eisenlohr's analysis he assumes a prism of matter moving bodily through a mass of quiescent ether. In Michelson and Morley's experiment the water was fed from an upper to a lower tank, passing on its way through the experimental tubes. The conditions of the two experiments do not seem to be necessarily the same. The bounding surface between air and water is moving with a very small velocity in the apparatus of Michelson and Morley, and the observations are made through a fixed region of space. It is not clear that this difference is of importance, but it seems possible that it may be, in determining the effects for different velocities.

The close agreement between the observed value of the velocity coefficient for the moving ether and the value computed on the assumption of an actual condensation of the ether, is, of course, a very worthy consideration. Still it seems very improbable that such a condensation can really take place. The ether may lag behind the moving water

without any condensation, and the other phenomenon requiring a greater density in matter than exists in free space, may, perhaps, receive other explanations that do less violence to our ideas. Ether, in which the complex molecules of matter are entangled, certainly might act as if it were more dense without really being so.

What the experiment of Michelson and Morley seems to show is that the ether is swept along by the water, but lags behind. The question of density appears to me still to be an open one. Maxwell's experiment with a prism which was, as was then supposed, moving through ether at a speed of 18.6 miles per second, seems to have a very different relation to Fresnel's theory if the ether at the earth's surface is moving with it.

It does not seem hopeless to repeat the experiment of Michelson and Morley on a railway coach, with water or carbon bisulphide at rest in the tube, if the road-bed and the car selected are of the best construction, and the apparatus is elastically supported.

It would be necessary, probably, to rigidly connect the observer's seat and the water tube, and to support them, with the observer, by helical steel springs surrounded by rubber tubes filled with glycerine to dampen the vibrations.

A speed of forty miles per hour will more than compensate for the suppression of one water column, which will be replaced by air. This is precisely the form of experiment upon which Eisenlohr's analysis is based. In this form the conditions of the experiment are capable of great variation. The car becomes really the moving body, and the transparent region within through which the light passes, may be shielded by any kind of opaque matter. Whatever the results may be, they can hardly fail to add greatly to our knowledge of the effect of moving masses upon the luminiferous ether.

LETTERS TO THE EDITOR.

* * * Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.

On request in advance, one hundred copies of the number containing his communication will be furnished free to any correspondent.

The editor will be glad to publish any queries consonant with the character of the journal.

Jugglery.

IN *Science* for Aug. 14 there was an inquiry, quoted from *Illustrated News of the World*, as to the source of a certain statement regarding the apparently marvellous feats of Indian jugglers. In this statement it had been suggested that the spectators had been hypnotized by the performer, and hence imagined they saw something which the "snap-shot" of a kodak proved did not exist at all. I remember reading this very circumstantial account in an evening paper, and cut it out to send to India. After some search I have found the original reference. The story, as a quotation from the *Chicago Tribune*, was published in the *Evening Star* of Washington, D.C., on Aug. 30, 1890. Its author, Frederick S. Ellmore, purported to be a graduate of Yale College, and to have travelled extensively in India with an artist friend, a Mr. Lessing. It has since transpired that no person by this name is a graduate of Yale.

To my mind the story shows a good many signs of being on the Mulhatton style, and could easily have been written by some one who had never been in India. It is very plain that no juggler could by any possibility hypnotize a mixed audience all the time changing. Those who have seen the original growth of the mango-tree under the manipulations of the performer, who was stark naked except for a *lungooti* (breech cloth), will be inclined to smile at Hermann's explanation given in *Science*. My father has spent twenty years in India, and has seen this performance repeatedly. He has noted one singular coincidence, in that the tree is never made to grow except in the season when the leaves and fruit of the mango-tree are in proper order for the exhibition.

H. A. HAZEN.

Washington, D.C., Aug. 18.

The Rain-Makers.

EVERY reader of *Science* has seen the recent telegram from Midland, Texas, Aug. 11, "Preliminary explosions made yesterday; raining to-day." It may be well, with the apparent brilliant success of this remarkable undertaking before us, to examine this question at length.

Ever since the time of Plutarch the idea has been prevalent that great battles are invariably followed by rain. In the earliest times, before the introduction of gunpowder, it was thought that exhalations from the dead bodies might assist in precipitating the moisture, but in more recent times there has been a well-nigh universal belief among soldiers that heavy cannonading or firing will produce rainfall. Whence comes this common thought were there not a fact to originate and back it up? We may as well ask, whence comes the well-nigh universal belief that the moon has a marked influence upon the weather? Now it is well known that in the latter case, most careful researches extending over a century have shown either no effect at all, or one that was either contradictory in different periods, or almost inappreciable.

Now since the moon's influence must be almost infinitesimal, as every one can readily see, it would be difficult, perhaps, to determine its exact relation to weather changes which are so complex, but it would seem far otherwise as to the determination of the exact effect of explosions upon the atmosphere. A careful study of this question has been made by Mr. Edward Powers, who has found that 158 of the smaller and larger battles of the Rebellion were followed by rain, usually twenty-four hours afterward. It might be asked, is it possible that this list comprises all the cases? While some of the battles may have been omitted, yet it seems highly probable that a diligent search must have revealed most if not all there were. It is a most remarkable fact that no mention whatever is made of the battles that were not followed by rain, and yet in an inquiry of this kind it is very essential to examine both sides of the question. During the war of the Rebellion there were over 2,200 battles, on an average probably as severe as the average of the 158 above mentioned; that is to say, about seven per cent of the battles were followed by rain. Is it at all incredible that seven per cent of these battles were followed by natural rain? In the case of the battle of Bull Run, which Mr. Powers especially picks out as a bright and shining example of his theory that explosions produce rain, it has been ascertained that there was a heavy rain in South Carolina on the first day of the battle. This rain had been previously noted farther south, and this was the rain felt at Bull Run. It would be very interesting to look up the question of how many of these 158 apparent successes were due to natural causes, but unquestionably almost all, if not all, may be ascribed to that cause. It is interesting to note that it is thought this influence may extend twenty-four hours after the explosions cease. This inference, however, is hardly tenable, for the reason that the current in which these explosions take place is borne along at the rate of 20, and, in higher strata, at 30, 40, 50, and more, miles per hour, so that the specific influence from them will be carried at least 500 miles away in twenty-four hours. If we wished to determine the effect, we would need to go to that distance from the spot where the explosions were made, and the rain that came in twenty-four hours at that spot could not by any possibility be due to the explosions.

There is only one other point to be noted here. It has been stated that while the Central Pacific Railroad was being built across the Sierra Nevada Mountains, it was necessary to explode hundreds of kegs of gunpowder every day, and this tremendous fusillade was accompanied by torrents of rain, which had never been noted before in that region, and have not been noted since. If this is a fact, it was a most remarkable phenomenon, and it would seem as though it might be established by indubitable evidence. It is a little singular that no dates or definite statements which could be verified have been given. Present rainfall reports show an abundance of rain except in two or three of the hottest months, and it seems entirely probable that persons who had been accustomed to the remarkable and long continued dryness of the plains were struck by what appeared like most abundant moisture in the mountains just at a time when there was none on the plain.

We are now prepared to investigate the value of the telegraphed result from Texas. Any one who will examine the weather maps, now sown broadcast over almost the whole country, will find that on the 11th instant there was a natural rain which extended over the whole of Texas and adjacent regions. One thing seems very evident, that absolutely no rain can be obtained out of a dry atmosphere. If the explosions can produce rain in limited quantities, yet their influence must always be exceedingly slight, and the expense of the explosions must always be all out of proportion to the amount of good done. Professor Harrington has well said that these experiments begin at the wrong end. The time may be ripe for experimenting in the atmosphere upon the cause of rain, about which we now know practically nothing. It must be conceded that until we do first experiment upon the cause of rain, all time and money used in making gross explosions will be wasted.

H. A. HAZEN.

Washington, D.C., Aug. 17.

P. S. — Since writing the above, a telegram from Midland, dated Aug. 19, states that several more preliminary explosions were made on Aug. 18, and that immediately thereafter rain began falling and continued over four hours. An examination of the weather maps for Aug. 18 has shown that the rain began, to the north of Texas, at least eleven hours before the explosions, and covered an area of over 800,000 square miles. The final tests were to be made on the 20th.

H. A. H.

Experiments on Snake Locomotion.

It is a well-known fact that a snake moves along over the ground by means of adjustable plates or scutes situated on the ventral surface of the body. How the movements of these scutes succeed each other, and what relations the different convolutions of the body bear to one another, are not so satisfactorily known. Whoever has examined the mechanism of the scutes will, I think, come to the conclusion that they must be moved by the costal muscles, and that this movement must consist in a posterior depression by which the scute offers an opposing surface to the ground. In all probability this depression is both downward and backward, thus imparting a slight forward impulse to the body. If this view of the case is correct, we would naturally expect that the act of locomotion would consist in some sort of fusion or succession of these minute individual impulses. Owing to the rapidity with which these movements are normally executed it is impossible to analyze or define their exact nature, and accordingly experiment seems to offer the only trustworthy guide to a solution of the problem. In experimenting, however, we are encountered with great difficulties at the very outset.

If we could succeed in recording the movements of an animal by means of apparatus, the construction of which was ever so delicate, can we rely on this record as a faithful expression of the natural and unimpeded movements of the animal? We can hardly feel at liberty to do so. There are at least two causes which may vitiate the results: (1) the animal is excited and annoyed by the experiments and does not act naturally; (2) the apparatus used in the experiment may directly impede the organs in the discharge of their normal functions. But while these difficulties render it impossible to obtain a record which is trustworthy in all respects, yet approximate results may be obtained which will lead up to a correct solution in the end.

In considering the locomotion of the snake, it may be well first to state what we know and what we do not know. We know that the snake generally moves on a horizontal or inclined plane, rarely elevating any part of the body to a very considerable distance above that plane. It sometimes moves with its body straightened and in a straight line, but far more frequently the body is placed so as to resemble a sinusoid, and its movements have a lateral and a direct component. The larger convolutions of the body occur in those portions which have the greatest mean diameter. The convolutions do not form simultaneously, but each travels the whole length of the body, like a wave of water, being at no two consecutive moments composed of the same parts. These waves succeed each other on opposite sides of the body, thus producing a reciprocal curve. Each wave travels from the head towards the tail, and

drives its predecessor of opposite phase before it until it disappears at the tail. At times the curves do not shift to alternate sides of the body, but successive curves are formed on the same side. This motion, be it observed, is totally distinct from the reciprocal curvings described above. So much for what can be directly observed. But we cannot tell by direct observation the curves which different parts of the body would describe were they to mark the surfaces over which they move. Nor can we observe the movements of the scutes, or their correlations with the movements of the body as a whole. If we are to understand these activities, we must do so by experiment.

The following was the method of experiment employed. Short pieces of thread were run through bits of sponge saturated with ink, and these were tied around the body of the snake so that the sponges would come on the ventral surface. When these were securely tied the animal was placed on a strip of coarse paper and allowed to move. So long as the sponges were properly supplied with ink every movement made by the parts of the body thus provided was marked on the paper. Now if the different sponges were soaked with ink of different color, the simultaneous movements of different parts would be recorded, and, theoretically, with a sufficient number of sponges placed at proper intervals we would secure a complete record of all the bodily movements during a sustained period of locomotion. Such a record, however, it is impossible to obtain, for reasons which need not be mentioned.

The curves obtained by this method were by no means uniform, but varied both with the direction and velocity of the movements, and apparently with the caprice of the animal. The separate curves described by different parts of the body cannot be said to be characterized by any marked idiosyncracies. On the contrary, they appear to vary at random, now being marked by acute angles followed by beautifully rounded sinuosities, which in turn may be succeeded by protracted and irregular curves or at times figure-of-eight tracings. There is this distinction, however, between the curves described by the middle of the body and those of the distal parts. They have not so great an amplitude and are less variable. Contrary to what we would naturally expect, the synchronous curves described by different parts of the body have no discoverable agreement either in phase or in form.

From this description it might be inferred that very little of value could be derived from a study of such curves. But further study shows this inference to be ill-sustained. In interpreting the curves it is well to remember that they do not represent perfectly normal movements, because the scutes over which the sponges were tied were impeded in their action, and because rough paper is even smoother than the average ground over which the snake moves. Owing to this last circumstance the scutes would slip, and the curves would thus be shorter.

After making due allowance for the conditions which embarrass the experiments, we may perhaps still speak with some degree of confidence as to the general results, and possibly discover the existence of some fundamental laws. Perhaps the most striking fact about all the curves is, that, with very rare exceptions, they are described on opposite sides of an ideal line which may be called the axis of motion. While they demonstrate that the snake's body is capable of an almost infinite variety of movements, yet lateral movements generally prevail. There is also a tendency to consecutive repetitions, sinuosities following sinuosities, and angularities following angularities. The most irregular curves are described when the animal executes slow and hesitating movements. In this case the curves may be extended on both sides of the axis of motion, or confined to one side, when the curve is a tolerably regular succession of semicircles whose adjacent arcs form cusps. During rapid motion the sinusoid is by far the most common curve described. In fact, it may be regarded as the typical curve described by the snake's body.

It is instructive to note that when the curve assumed by the body is a sinusoid, then the curves described by different points of the body are sinusoids. The relation becomes intelligible when we reflect that the curves of the body partake of a wave-like motion, each particle vibrating, as it were, from the crest of one convolution across the axis of motion to the crest of a succeeding

convolution of opposite phase, and all the while progressing in a general direction parallel to the axis of motion. At this point it may be asked, what advantage is secured by this curvilinear motion? The chief advantage seems to be that those portions of the body placed transversely to the axis of motion furnish better fulcra from which the anterior parts of the body may be projected forward. If this is the correct explanation, then, during the forward movement of that part of the body anterior to the transverse flexure, the scutes are for the most part passive, and the anterior parts are projected by the median muscles. This seems to be a good reason for believing that the scutes do not act in continuous succession from before backwards, but intermittently and perhaps to some extent simultaneously, being interrupted by shoves and pulls which annul and complicate their action. The problem of their motion, however, is a difficult one, and more experimentation is needed before the laws of their action can be confidently and fully formulated.

J. LAWTON WILLIAMS.

Hornellsville, N.Y., Aug. 18.

Black and Bright Bulb Thermometers in Vacuo.

In reply to an inquiry in this journal for Aug. 7, I would say that the formulæ for these radiation thermometers will be found in the "Annual Report of the Chief Signal Officer for 1885," pp. 131-134. Professor Ferrel has also made an exhaustive study of

a special investigation of a large number of these thermometers, which will be found in "Professional Papers, Signal Service," XIII., pp. 34-50.

Several notices have appeared in *Nature* from time to time. It would seem that serious discrepancies have been found in these instruments, and it is still a mooted question as to their source. Professor Ferrel found, as was to be expected, that the ventilation of the bulbs was a most important factor.

H. A. HAZEN.

Washington, D.C., Aug. 18.

AMONG THE PUBLISHERS.

THE most timely feature of the September number of the *New England Magazine* is an article on the late "Edward Burgess and His Boats." The writer is A. G. McVey, the yachting editor of the Boston *Herald*.

—D. C. Heath & Co., Boston, will issue, about the first of September, "Andersen's Marchen," selected, arranged, and edited, with notes and vocabulary, by Professor O. B. Super of Dickinson College, Pa.

—In the *Atlantic Monthly* for September John Fiske has a paper on "Europe and Cathay," which discusses the reasons why early Norse discoverers of America were not its real discoverers. In the same number is a description of the Japanese Feast of Lanterns and the Market of the Dead, by Lafcadio Hearn.

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—“Practical Work in Organic Chemistry,” by Frederick William Streatfeild, just published by Spon, is one of the Finsbury Technical Manuals. The Finsbury Technical College gives instruction in both day and evening classes to those who wish to qualify themselves for filling positions requiring technical skill. The author, who is the demonstrator of chemistry at Finsbury, after describing the operations in organic chemistry, such as purification, crystallization, determination of melting point, and the mode of analysis, devotes most of his space to oxalic acid, alcohol, the fats and oils, and the coal-tar products.

—Everyone interested in the betterment of public roads and highways should read the article, in the September *Lippincott's Magazine*, by John Gilmer Speed on “Country Roads and Highways.” That we have very bad roads in this country is an accepted fact, but few realize how very bad they are in comparison with those of many foreign countries. Besides calling attention to the wretched condition of our roads, and telling what has been done

in different States for their betterment, Mr. Speed offers some valuable suggestions.

—The Academy of Music in this city will open its coming season on Thursday, Sept. 3, with a romantic spectacular play called “The Soudan.” This drama was produced, and ran for two seasons, at the Drury Lane Theatre, London, under the title of “Human Nature.” The story, which is a strong one, deals with events which occurred during the campaign for the relief of Gen. Gordon and other Europeans, who were held prisoners at Khartoum by the Arabs, during the war in the Soudan. The scenes, which are laid in England and Egypt, afford an excellent opportunity for a display of grandeur such as few other attractions of the kind can boast of. The Arab city, attacked and carried by English soldiers, or the surging crowd at Trafalgar Square, London, cheering and shouting words of welcome to the victorious Guards, makes a never-to-be-forgotten stage-picture.

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